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ORIGINAL PAPER

Impact of land-use management on nitrogen transformation in a mountain forest ecosystem in the north of Iran

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Abstract: Soil inorganic N is one of the most important soil quality indexes, which may be influenced by land-use change. The historical conversion of land-use from native vegetation to agriculture resulted in sharp declines in soil N dynamics. This study was conducted to determine the soil inorganic N concentrations and net N mineralization rate in four common types of land-uses in the mountain forest area in the north of Iran, namely arable land, pine plantation, ash plantation, and beech stand. The soil samples were taken from top mineral soil layer (5 cm) in each site randomly (n=6) during August- September 2010. Beech stand and ash plantation showed significantly higher total nitrogen compared with arable land and pine plantation, while extractable NH_4^+-N concentration was significantly greater in Beech stand compare to arable soils (p<0.05). No significantly difference was found in Net N mineralization, net nitrification and net ammonification rates among different land-uses. Results showed that net N mineralization and ammonification were occurred just in the soil of Ash plantation during the incubation time. Our findings suggested that conversion of Hyrcanian forests areas to pine plantation and agricultural land can disrupt soil natural activities and affect extremely soil quality.

Keywords: soil quality; net N mineralization; nitrogen dynamic; land use; Hyrcanian forest; Alandan.

Introduction

The destruction of environment can influence extremely sustainable development in a region by unsuitable actions and decisions in use of land. The term, land degradation is generally used to state a loss or reduction of land productivity as a result of human activity (Sing et al. 2007; Marzaioli et al. 2010). Deforestation, overgrazing, unsuitable agricultural practices and industrial activities are known as the main causes of vegetation and consequently soil destruction (UNEP 1993-94). In many of countries, forest conversion to agricultural land may result in ecological stress (Sharma 2000). Soil quality as the combination of soil physical, chemical and biological properties may be altered by changing in soil conditions affected by land use type (Brejda et al. 2000; Islam and Weil 2000; Caravaca et al. 2002; Sanchez-Maranon et al. 2002).

It has been stated that land use (arable vs. pasture) influenced biological soil quality more than soil type (Fromm et al. 1993). The biological properties of soil are very sensitive to small-changes in soil condition. Nitrogen availability and Net N mineralization rates have been used to assess soil quality as the most appropriate soil biological indices (Andrews et al. 2002; Marzaioli et al. 2010). Although, inorganic nitrogen is the basic element of land productivity in terrestrial ecosystem, the imbalance in N mineralization/ immobilization rate and subsequently nitrate (NO_3^-) leaching accompanied with base cations can lead to reduction of soil quality (knoepp et al. 2000; Dannenmann et al. 2007).

The forest destruction and its conversion to agriculture lands and reforestation by broad-leaved and coniferous species are the common forms of forest land-use in the mountain Hyrcanian forest in north of Iran. The present study aimed to investigate the effect of land use change on the concentration of inorganic N and net N mineralization rates in different land uses.

Materials and methods

Site description

Our study was conducted in Alandan forest, a part of Hyrcanian region in the north of Iran (latitude, 36°13' N; longitude, 36°10'

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E). The experimental area was situated in 1,000 m above sea level and average annual rainfall and temperature were 858 mm and 11.9°C, respectively. Soil type is Brown forest soil. Four study sites were selected based on major land-use types included managed Beech stand, Pine plantation, Ash plantation, and agriculture land. The dominated tree species was *Fagus orientalis* Lipsky., *Pinuse nigra* Arnold. and *Fraxinus excelsior* L. in beech stand, pine plantation and ash plantation, respectively. Wheat and barley are planted as rainfed farming in arable land (AL).The natural background of whole area was pure Oriental beech forest which has been converted since 30 years ago. The investigated sites located close to each other in nearly the same topographic situation (Fig. 1).

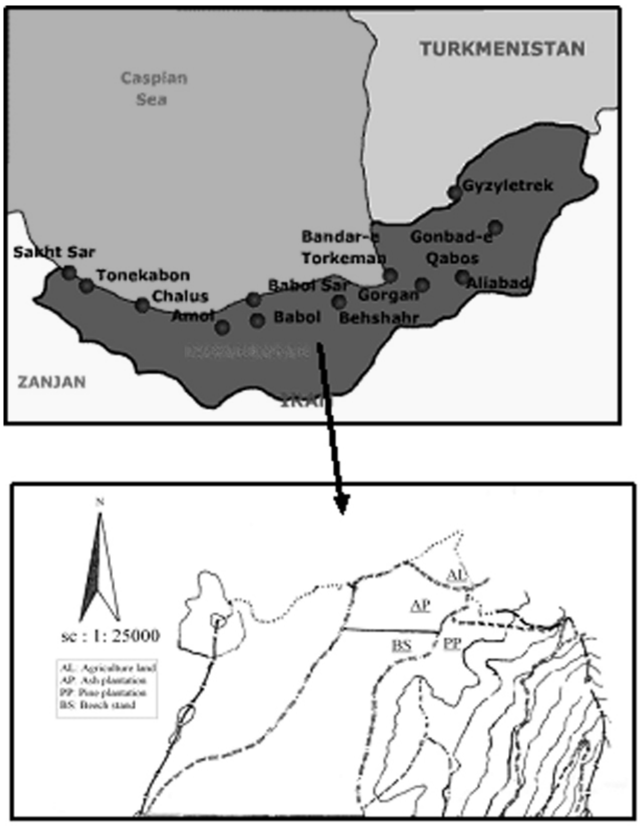

Fig1. Map showing the location of study different land use types

Soil sampling

The buried-bag technique (Eno 1960; Binkley and Hart 1989) was used to estimate net N mineralization, nitrification and ammonification rate. We performed tow sampling, first in 15 August, and a second in 15 September 2011. Six pair random soil samples were taken from the top soil layer (0–5 cm) at each land-use with an 8-cm metallic core. The litter layer was removed from the soil surface before samplings. One sample of each pair soil sample was used to determine initial concentrations of extractable NH_4^+ and NO_3^- and the other was placed in a polyethylene bag and buried in situ. The incubation period was 35 days. Samples were chilled during transport back to the laboratory and refrigerated (4ºC) until processed in the laboratory.

Soil extraction and chemical analysis

In the laboratory (2 mm mesh) and a subsample was used to determine moisture content (105ºC, 24 h). Fresh soil samples (10 g) were extracted with 100 ml of 2 M KCL for 60 min. Soil extracts were filtered with Whatman no.1 filter paper and filter blank correction were applied. NH_4^+ concentration was measured using a manual indophenols colorimetric method (Dorich and Nelson 1983). NO_3^- concentration was measured using the manual Cd reduction method (APHA 1998). Soil Organic carbon was determined by Walkley and Black procedure and total N by modified Kjeldhal digestion. Soil pH (1: 2.5 soil:water) was measured by using glass electrode (Singh et al. 2007).

Data calculation

Net N mineralization was calculated as the difference between NH_4^+ and NO_3^- concentrations in the incubated sample and the NH_4^+ and NO_3^- concentration in the initial samples. The net increase in NO_3^- and NH_4^+ was used to indicate net nitrification and ammonification rates, respectively (Duran et al 2009).

Statistical analysis

The data were analyzed using one-way analysis of variance (ANOVA) after checking the assumption for parametric test. The Duncan test was used to determine significant differences at the level of (p<0.05). SPSS v.16 software was applied for all statistical analyses.

Results and discussion

Soil properties

Table 1 shows the soil variables in first (15 August) and second (15 September) sampling date in different land uses. The organic carbon (%) was significantly (p<0.05) higher in ash plantation (6.79%, 6.14%) compared with pine plantation (2.89%, 3.01%) and arable land (3.14%, 2.92%) in both sampling date.

The ash plantation showed significantly (p <0.05) higher total nitrogen (0.69%, 0.85%) compare to pine plantation (0.27%, 0.39%) and arable land (0.28%, 0.3%) in first and second sampling date, respectively.

The easily decomposable and nutrient-rich litter of ash may support large population of micro-organisms, which could contribute to an increase in soil N (Fried et al. 1989; Norden 1994a; Hagen-Thorn et al. 2004). The low amounts of organic carbon and total nitrogen in pine plantation may be related to slow litter decomposition in pine species. In agreement with the result of the present study, Chen and Li (2003) claimed that changes from native forests to larch plantations resulted in significant decline

in soil C and N.

It is commonly known that agricultural practices and cultivation may cause an immediate and rapid loss of soil organic carbon (Davidson and Ackerman 1993). There are variety of mechanisms which involve in reduction of SOC because of decreasing in C inputs and outputs. The removal of annual crop biomass through harvest reduces the quantity of C inputs to soil compared to perennial native vegetation (Imhoff et al. 2004). The physical disturbance of tillage increases SOC decomposition rate, which occur both by measuring soil respiration immediately after tillage and by comparing of soil C levels in agricultural fields with or without tillage (Collins et al 2000). Tillage and the lack of plant cover on agricultural fields enable soil erosion to occur by water and wind. N loss from arable land are took place via increasing decomposition rates from tillage, erosion, gaseous losses from microbial processes, and decreasing plant inputs due to crop removal (Mclaunchlan 2006).

Table 1. Means (±SE) of organic C (%) and total N (%), C: N ratio, soil moisture (%), pH, extractable NH_4-N and No_3-N (mg kg $soil^{-1}$).

Soil properties	sampling date	Beech	Pine	Ash	Agriculture
% C	August	5.54(±0.48) ^{b}	2.89(±0.15) ^{c}	6.79(±0.19) ^{a}	3.14(±0.36) ^{c}
	September	5.45(±0.91) ^{a}	3.01(±0.18) ^{b}	6.14(±0.34) ^{a}	2.92(±0.12) ^{b}
% N	August	0.57(±0.07) ^{a}	0.27(±0.03) ^{b}	0.69(±0.04) ^{a}	0.28(±0.01) ^{b}
	September	0.57(±0.11) ^{ab}	0.32(±0.05) ^{b}	0.85(±0.15) ^{a}	0.3(±0.02) ^{b}
C:N ratio	August	10.14(±0.87) ^{NS}	11.08(±0.97) ^{NS}	9.98(±0.38) ^{NS}	10.36(±1.64) ^{NS}
	September	9.95(±0.87) ^{NS}	10.02(±0.86) ^{NS}	7.86(±0.75) ^{NS}	10.35(±0.86) ^{NS}
Moisture	August	21.20(±1.78) ^{a}	13.13(±0.86) ^{b}	15.90(±0.72) ^{b}	12. 66(±0.77) ^{b}
	September	22.98(±1.9) ^{a}	13.99(±0.9) ^{b}	16.62(±0.75) ^{b}	13.43(±0.8) ^{b}
pH	August	6.62(±0.08) b	6.87(±0.08) ^{ab}	7.34(±0.06) ^{a}	7.18(±0.05) ^{a}
	September	6.54(±0.06) ^{b}	6.95(±0.1) ^{ab}	7.4(±0.08) ^{a}	7.23(±0.06) ^{a}
NH_4-N	August	60.68(±15.03) ^{a}	41.78(4.71) ^{ab}	30.12(±3.61) ^{ab}	21.77(±6.18) ^{b}
	September	22(±3.53) bc	24.19(±3.58) bc	45.4(±12.7) ab	16.23(±1.25) c
No_3-N	August	24.47(±4.71) ^{NS}	22.73(±2.71) ^{NS}	28.68(±2.01) ^{NS}	28.73(±2.77) ^{NS}
	September	17.43(±4.35) ^{NS}	17.72(±3.43) ^{NS}	21.09(±3.17) ^{NS}	22.49(±3.17) ^{NS}

The different letters indicate significant differences among the sites for each sampling date at the level of p<0.05.
NS non-significant

C/N ratio showed no significant difference between different sites for both sampling date, but highest C/N ratio (11.08, 10.02) was found in pine plantation and its lowest ratio were observed in ash plantation (9.98, 7.86) in both sampling date.

The forest floor and upper mineral soil layer in coniferous stand showed higher C/N ratio, lower nutrient content and slower litter decomposition rate compare to broadleaves (Legare et al. 2001; Augusto et al. 2003; Barbier et al. 2008). The lower C/N ratios under Ash canopy may reflect differences in N (higher annual input of N in Ash litter) and/or faster rates of litter decay. Due to the rapid turnover of ash litter, nitrogen will become less sequestrated in the forest floor and can be incorporated faster in the mineral soil (Norden 1994b).

Soil moisture were significantly (p<0.05) higher in Beech stand (21.20%, 22.98%) than in the other sites for both sampling date. Adding of organic matter to soil may lead to increase quantity of SOC in the upper mineral soil layer and consequently soil moisture (Mclauchlan, 2006).

Ash plantation showed significantly greater pH compared with beech stand and arable land for both sampling date. The lower pH in beech forest compared to other land uses can be explained by slower litter decomposition of this species, which leads to the production of organic acids and also delays the return of base cations to the soil (Hagen-Thorn 2004).

Inorganic N

A significant difference in ammonium-N concentration was found between beech stand (60.68 mg/kg) and arable land (21.77 mg/kg) in August and between ash plantation (45.4 mg/kg) and arable land (16.23 mg/kg) in September, while no significant difference was found in NO_3-N concentration among different sites (Table1). The higher ammonium concentrations may be related to higher rates of N mineralization occurring in soil of different land use type (Garten 1993). Increase in N mineralization rates and microbial activity have been reported as an effect of transient increase in temperature, water content, pH, and labile sources of C and N for microbes (Rutigliano et al. 2007). Those favorable conditions have been occurred in Ash plantation significantly. Nitrate concentration tended to be higher in arable land on both sampling date than in the beech stand and pine plantation (Table.1). In arable soil, heavy nitrogen fertilization can be a major source of excessive nitrate because the crops usually take up only a portion of applied nitrogen. Increasing in nitrate concentration following fertilizer application may lead to decline or inhibit microbial ammonium production (Brady and Weil 2008).

Net N mineralization

Net N mineralization, net nitrification and net ammonification rates showed no significant difference between studied sites. These indexes indicated a negative rate in the most studied sites with the exception for ash plantation in net N mineralization and net ammonification rates (Fig. 2).

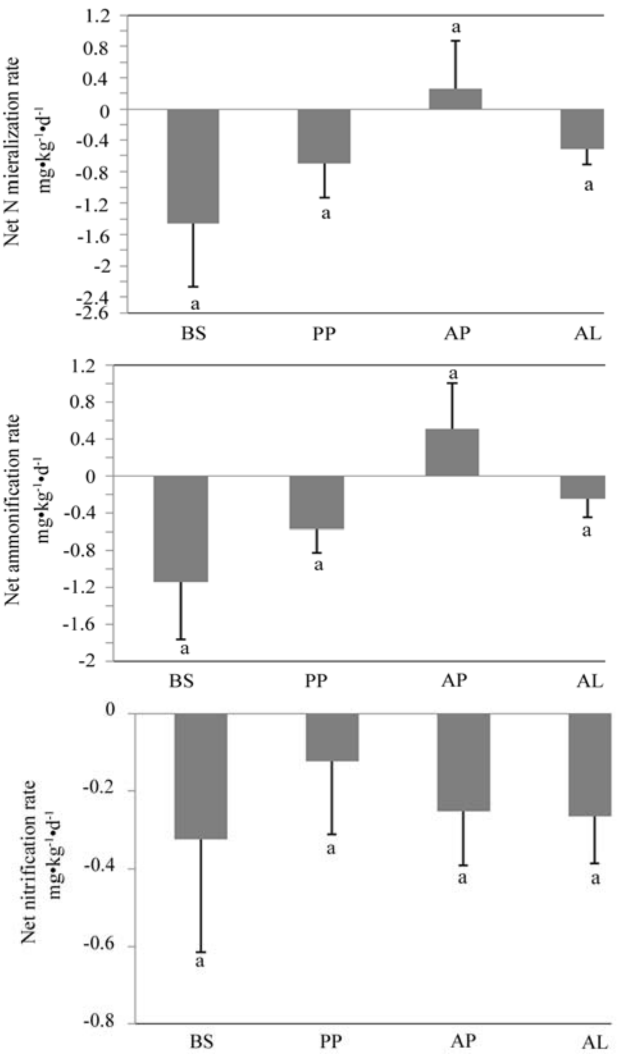

Fig. 2 Net N mineralization, ammonification and nitrification rates in the top mineral soil (5 cm) layer. Error Bars represent standard error.BS---Beech stand, PP---Pine plantation, AP---Ash plantation, AL---agriculture land.

The differences in ammonification and N-mineralization rates are attributed to site variations in soil organic matter, temperature and soil water availability (Singh 2007). These differences were related to difference in vegetation cover and soil characteristics (Owen et al. 2003). Plant species can influence nitrogen dynamics and alter the patterns of mineral N (Knops et al. 2002). High N content, low C/N ratio, relatively high pH and high moisture of mineral soil (Table.1) as well as fast litter decomposition rate may cause high level of Net N mineralization in Ash plantation (Brady et al., 2008). In pine plantation and beach stand, closed canopy may cause unfavorable microclimatic conditions for decaying slowly decomposable litter of pine and beech, which lead to decrease in mineralization rates (Duran et al. 2009).

Conclusion

To our knowledge the present study is the first try to report soil net N mineralization in forest lands of Hyrcanian region, Iran. By identifying N dynamics, there is an appropriate opportunity to compare the soil quality in different land-uses. Results of Buried-bag experiment in the present study showed that net N mineralization and ammonification were occurred just in soil of Ash plantation during the incubation time. The ability of Ash species to improve soil properties (High N, C, moisture and High ammonium concentration) can lead to net N mineralization and ammonification in this site. According to our findings, N dynamics can be influenced by conversion of forest ecosystem. Thus N concentration and its various forms can use as the key indexes to evaluate the effects of land management on soil quality.

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References

Andrews SS, Mitchell JP, Mancinelli R, Karlen DL, Hartz TH, Horwath WR, Pettygrove GS, Scow KM, Munk DS. 2002. On-farm assessment of soil quality in California's central valley. *Agron J*, **94**: 12–23.

APHA. 1998. Cadmium reduction method. In: Franson, M.A.H. (ed.), *Standard Methods for the Examination of Water and Wastewater*. Washington, DC: the American Public Health Association (APHA), the American Water Works Association (AWWA), and the Water Environment Federation (WEF), pp. 4–118.

Augusto L, Dupouey J, Ranger J. 2003. Effects of tree species on understory vegetation and environmental conditions in temperate forests. *Ann For Sci*, **60**: 823–831.

Augusto L, Ranger J, Binkley D, Rothe A. 2002. Impact of several common tree species of European temperate forests on soil fertility. *Ann For Sci*, **59**: 233–253.

Barbier S, Gosslin F, Balandier P. 2008. Influence of tree species on understory vegetation diversity and mechanisms involved – A critical review for temperate and boreal forests. *Forest Ecology and Management*, **254**: 1–15.

Binkley D, Hart SC. 1989. The components of nitrogen availability assessments in forest soils. *Adv Soil Sci*, **10**: 57–112.

Brady NC, Well RR. 2008. *The Nature and properties of soils*. Pearson Prentice Hll, p.965.

Brejda JJ, Karlen DL, Smith JL, Allan DL. 2000. Identification of regional soil quality factors and indications in Northern Mississippi Loess Hills and

Palouse Prairie. *Soil Sci Soc Am J*, **64**: 2125–2135.

Caravaca F, Masciandaro G, Ceccanti B. 2002. Land use in relation to chemical and biochemical properties in semiarid Mediterranean environment. *Soil Till Res*, **68**: 23–30.

Collins HP, Elliott ET, Paustian K, Bundy LG, Dick WA, Huggins DR, smucker AJM. 2000. Soil carbon pools and fluxes in long-term corn belt agroecosystems. *Soil Biol & Biochem*, **32**: 157–68.

Dannenmann M, Gasche R, Papen H. 2007. Nitrogen turnover and N_2O production in the forest floor of beech stands as influenced by forest management. *J. Plant Nutr Soil Sci*, **170**: 134–144.

Davidson EA, Ackerman IL. 1993. Changes in soil carbon inventories following cultivation of previously untilled soils. *Biogeochemistry*, **20**: 161–93.

Duran J, Rodriguez A, Palacios JMF, Gallardo A. 2009. Changes in net N mineralization rates and soil N and P pools in pine forest wildfire chronosequence. *Biol Fertil Soils*, **45**: 781–788.

Eno CF. 1960. Nitrate production in the field by incubating the soil in polyethylene bags. *Soil Sci Soc Am Proc*, **24**: 277–279.

Fried JS, Boyle JR, Tappeiner JC, Cromack K. 1989. Effects of bigleaf maple on soils in Douglas-fir forests. *Can J For Res*, **20**: 259–266.

Fromm H, Winter K, Filser J, Hantschel R, Beese F. 1993. The influence of soil type and cultivation system on the spatial distribution of the soil fauna and microorganisms and their interactions. *Geoderma*, **60**: 109–118.

Garten Jr. 1993. Variation in foliar N abundance and the availability of soil nitrogen on Walker Branch Watershed. *Ecology*, **74**: 2098–2113.

Hagen-Torn A, Callesen I, Armolaitis K, Nihlgard B. 2004. The impact of six European tree species on the chemistry of mineral topsoil in forest plantations on former agricultural land. *Forest Ecology and Management*, **195**: 373–384.

Imhoff ML, Bounoua L, Ricketts T, Loucks C, Harriss R, Lawarence WT. 2004. Global patterns in human consumption of net primary production . *Nature*, **429**: 870–873.

Islam KR, Weil RR. 2000. Land use effects on soil quality in a tropical forest ecosystem of Bangladesh. *Agric Ecosyst Environ*, **79**: 9–16.

Knops JMH, Tilman D. 2000. Dynamics of soil nitrogen and carbon accumulation for 61 years after agriculture abandonment. *Ecology*, **81**: 88−98.

Legare S, Bergeron Y, Leduc A, Pare D. 2001. Comparison of understory vegetation in boreal forest type of southwest Quebec. *Can J Bot*, **79**: 1019−1027.

McLauchlan K. 2006. The Nature and Longevity of Agricalture Impacts on Soil Carbon and Nuttients: A Review. *Ecosystems*, **9**: 1364−1382.

Norden U. 1994a. Leaf litterfall concentrations and fluxes of elements by deciduous tree species. *Scand J For Res*, **9**(1): 9−16.

Norden U. 1994b. Influence of broad-leaved tree species on pH and organic matter content of forest topsoils in Scania, South Sweden. *Scand J For.Res*, **9**: 1−8.

Owen JS, Wang MK, Wang CH, King HB, Sun HL. 2003. Net N mineralization and nitrification rates in a forested ecosystem in northeastern Taiwan. *Forest Ecology Management*, **176**: 519−530.

Rutigliano FA, De Marco A, D' Ascoli CS, Gentile A, Virzo De Santo A. 2007. Impact of fire on fugal abundance and microbial efficiency in C assimilation and mineralization in a Mediterranean maquis soil. *Biol Fertil Soils*, **44**: 377−381.

Sanchez-Maranon M, Soriano M, Delgado G, Delgado R. 2002. Soil quality in Mediterranean mountain environments: effects of land use change. *Soil Sci Soc Am J*, **66**: 948–958.

Sharma PD. 2004. Managing natural resources in the Indian Himalayas. *J Ind Soc Soil Sci*, **52**(4): 314–331.

Sing RS, Tripathi N, Singh SK. 2007. Impact of degredation on nitrogen transformation in a forest ecosystem of India. *Environ Monit Assess*, **125**: 165−173.

UNEP 1993-94, Environmental Data Report-cited in TERI Report No. 97/ED/52 (1997).